Mapping Forest Composition in the Appalachians Using Data From EO-1 Hyperion, Landsat, and AVIRIS

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The objectives of this investigation were to evaluate the EO-1 Hyperion hyperspectral sensor for mapping forest composition and structure in rugged terrain and to compare its performance with that of AVIRIS and the Landsat 7 Enhanced Thematic Mapper Plus (ETM+). The study focused on species composition mapping with Hyperion, AVIRIS, and Landsat using a study site in the Green Ridge State Forest in western Maryland located in the central Appalachian Mountains (Figure 1). The area contains steep mountains and deep valleys, and elevations range from 200 meters to 700 meters. The forests are mostly mature although some areas have experienced forest fires and/or gypsy moth defoliation.

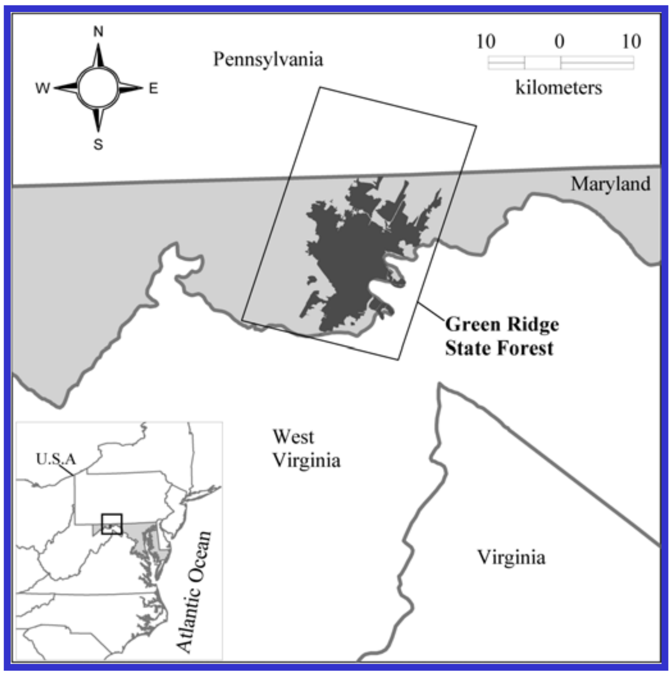


Figure 1. Study site.

Investigators used species identified in the Continuous Forest Inventory (CFI) database from the Maryland Department of Natural Resources as a starting point. This data came from 436 plots that had been sampled in 2000 and 2001. The investigators computed species abundance at the plot level; plot location was georeferenced using the Global Positioning System.

This study focused on the distribution of several common species in the area and particularly concentrated on separating oak classes. Since forest composition was mixed, they paid special attention to how the classifiers handled mixed composition. Analyses were limited to mature, fully stocked forests. The study used one high-altitude AVIRIS image acquired on May 14, 2000, and one Hyperion image collected on July 24, 2001. (Cloud cover at the time that an AVIRIS image was acquired closer to the Hyperion overflight prevented effective use of that image.) Figure 2 shows a true color composite of the May 14 AVIRIS image with the CFI plots identified (white dots).

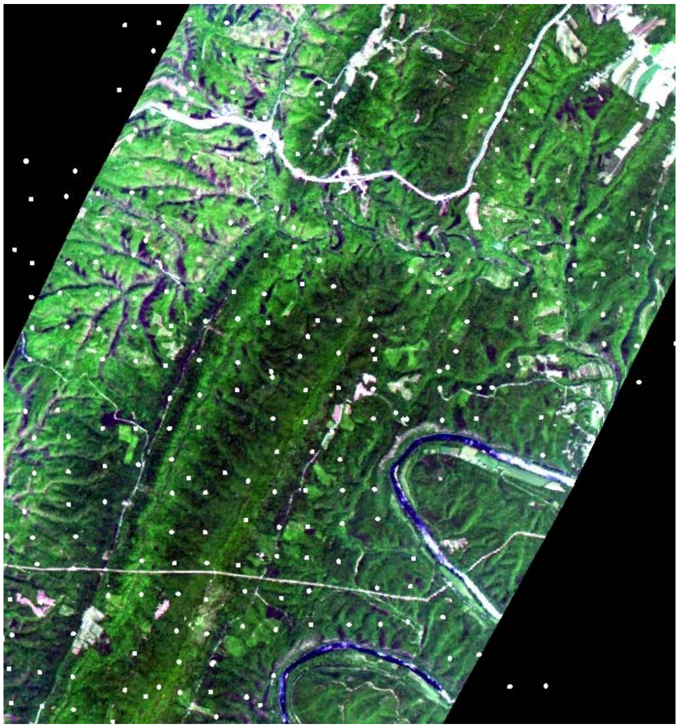


Figure 2. AVIRIS image, May 14, 2000, showing CFI plots.

Imagery from both AVIRIS and Hyperion was affected by the uneven topography in the area. Terrain normalization was carried out, which reduced effects of the terrain. Figure 3 shows the effect of terrain normalization on the Hyperion image. In general, classification accuracy was higher for the terrain-normalized images than the uncorrected images. However, the process seemed to reduce the superior signal to noise ratio of AVIRIS.

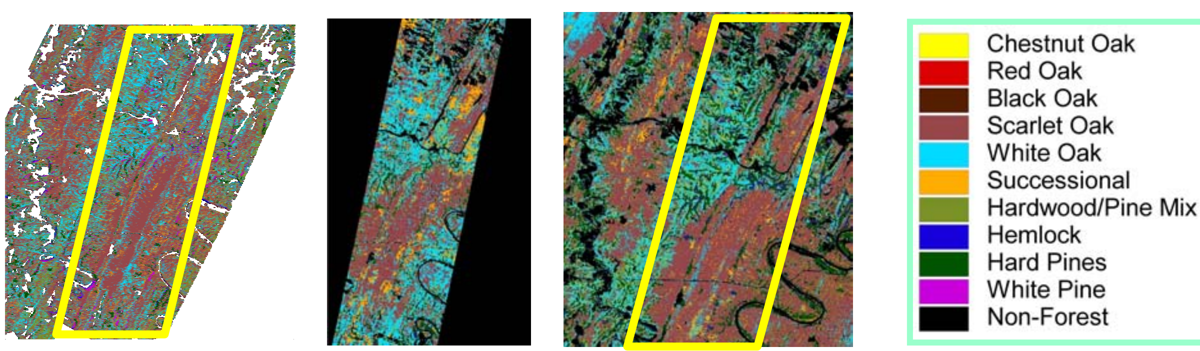
Original

Terrain normalized.

Figure 3. Hyperion, July 24, 2001.

Hyperion was able to distinguish 79.8% of major classes among both the broadleaf deciduous hardwoods and conifers accurately when divided into four major categories: red oaks, white oak, mixed conifer/oaks, and successional (a progression of a variety of trees) among the hardwoods and hard pine, white pine, and hemlock among the conifers. It identified 86.5% of red oaks and 71.0% of white oaks accurately as well as 76.9% of the mixed conifer/oaks group. It was able to further distinguish different species of red oaks, accurately dividing 59.3% into the proper variety of red oak: red, chestnut, black, or scarlet.

AVIRIS performed less well. It was able to distinguish 60.2% of major conifer and hardwood classes accurately and could further distinguish among only 9.7% of red oaks accurately. Landsat ETM+ data, derived from acquisitions on three dates, overpredicted conifers as well as the chestnut oak. In general, ETM+ fell between Hyperion and AVIRIS accuracies, being able to distinguish 72.8% of major classes of conifers and hardwoods and 45.7% of red oak varieties accurately. Figure 4 shows the distribution of trees as acquired by AVIRIS, Hyperion, and Landsat in the same region. However, it should be noted that AVIRIS imagery was acquired earlier in the year than Hyperion imagery, when leaves on hardwood trees were smaller and less distinguishable than leaf-growth later in the season when Hyperion imagery was acquired. Consequently, there was no analysis made of comparable AVIRIS and Hyperion imagery acquired at approximately the same time. The above results were based on preliminary analysis of the data. It is possible that AVIRIS' poorer performance was based solely on the fact that the leaves were smaller in size at the time of image acquisition.



AVIRIS **Hyperion** **ETM+**

Figure 4. Distribution of trees identified by AVIRIS, Hyperion, and ETM+ showing equal swatches.

Conclusions:

Hyperion provided no obvious benefit over ETM+ with the most general deciduous classes but was far superior with conifers. Some deciduous species also were distinctive. Using Hyperion appeared to improve the ability to map specific types, but mixed composition remains an issue. Comparison with AVIRIS in this study was negated by the time span between acquiring the two images. In addition, the AVIRIS image was acquired in early spring (May, prior to full leaf-out), which likely obscured spectral separability due to species composition. An earlier analysis of the summer AVIRIS imagery (which was limited in the number of classes mapped due to cloud cover) suggested similar performance between AVIRIS and Hyperion. Terrain normalization improved the results and accuracy of mapping detailed forest composition slightly better with Hyperion than with AVIRIS since the process seemed to reduce AVIRIS' inherent better signal-to-noise ratio. In other studies comparing Hyperion and AVIRIS data, classification using Hyperion exceeded classification using AVIRIS with the exception of identification of white oaks.